Mind the Gap: The Digital Dimension of College Access

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Introduction

Technology is central to the daily routine of university life. Around campus, libraries provide digital versions of scholarly journals and books, artists create with advanced design software, scientists simulate complex environments, and engineers and computer scientists continue to invent technologies that other disciplines will make use of in the future. In many universities, the course schedule has not been printed for years. Instead, students must search and enroll in courses and otherwise manage their academic schedule online. Final grades, financial aid accounts, and general university announcements are also provided exclusively online. Many institutions of higher education utilize course management software for online course discussions and document distribution. Implicitly, the university presumes that the study body will have the technology knowledge and skills to navigate through this digital environment.

Yet, without any formal technology prerequisites, students come to college with differing technological skills, stratified by gender, socioeconomic status, and racial backgrounds. Beyond skills, students' varied computing histories can result in a range of technology identities that impact their relationship with technology in their academic, social, and career aspirations. This paper draws from the results of a mixed methods study of undergraduates at a major research university to explore the

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development and impact of students' technological proficiency on their academic life. Specifically, this paper addresses two research questions:

1. *What educational and social factors are related to the reported technological proficiency level of university students?*
2. *How do students' levels of technological proficiency shape their engagement in their university work?*

Computing and the University Pipeline

Technology as an Invisible Academic Prerequisite

Though previous studies have examined the use of e-mail and Internet by college students (Jones, 2002; Sax, Ceja, & Teranishi, 2001), few have moved beyond participation counts to determine how students' technological proficiency levels shape their academic studies. Yet, even these basic indicators uncover a disturbing disparity between the use of the most basic information and communication technologies by undergraduates of different racial and economic backgrounds. The Annual College Freshmen Survey of 1998 reveals differences in Internet and e-mail use by race and socioeconomic status (Sax et al.). Asians and White students use electronic mail and go online more frequently than their Latino and African American classmates. The same discrepancies in technology use appear when comparing the connectivity of affluent students and poor students; poor students are less likely to use electronic mail and go online compared to their more affluent peers.

Students who are not using technology are potentially at an academic disadvantage compared to students who do use these new technologies. A college survey reveals that 79% of college students report that the Internet has a positive impact on their college academic experiences (Jones, 2002). This study also reveals that three of four college students use the Internet to communicate with classmates about group projects, and 68% subscribe to academic-oriented mailing lists related to their studies. Students who do not go online are forced to find alternative ways of communicating with classmates, accessing information for assignments, and managing their university records.

Since K–12 education and higher education resources and curriculum are typically state-specific, and because the research site of this study is in California, it is important to examine the particular technology expectations and opportunities in California universities and schools. California university instructors recognize the importance of these new technologies and note that "students' success in college has as much to do with their ability to find information as to recall it" (Intersegmental

Committee of the Academic Senates of the California Community Colleges and the California State University and the University of California, 2002, p. 35). However, though students may have basic computer skills, many students do not possess the fluency required to critically examine the validity of online information sources. For example, a library study of university undergraduates reveals that more than two thirds of students surveyed believe that a Web site created by the Arco Gasoline corporation would be an objective source of information regarding air pollution (UCLA Library Instructional Services Advisory Committee, 2001). Although some students are unable to analyze sources for accuracy and bias, 54% of faculty recommend or require using a Web browser for research, and 42% of faculty recommend or require students to evaluate Web sources. In addition, more than two thirds of faculty recommend or require their freshmen students to use e-mail (Intersegmental Committee of the Academic Senates of the California Community Colleges and the California State University and the University of California).

Besides individual recommendations and requirements by faculty members, there are currently no standard technology prerequisites for college freshmen. If students do not have the necessary proficiency required by college professors, they must seek out individual assistance. The Intersegmental Committee of the Academic Senates of California Colleges, the California State University, and the University of California (2002) state that "university faculty assumes that students who enter without . . . technological skills will demonstrate the habits of mind and self-advocacy to further their education" (p. 35). Since the freshmen year often is an overwhelming academic adjustment, seeking out noncredit workshops to learn basic computer skills adds an additional burden. If knowing technology is in fact a necessary prerequisite for higher education, it is critical that high schools prepare students with the technological knowledge required for academic success in college.

The Digital Opportunity Gap for K–12 Students

The "old digital divide": Access to the tools of technology. Early digital divide discussions focused almost exclusively on the technical component of the equity gap, including computer hardware, software, and more recently, broadband Internet access. This access divide still has not been bridged, and in many ways, has widened. Although some high schools do provide technologically and academically rich learning experiences for their students, others do not. In fact, students in some schools have minimal opportunities to simply use computers and go online. High schools attended by students of color and poor students provide less access to computers than students attending schools serving White and middle-class students. In California, students attending high schools in poor communities have a student-per-multimedia computer ratio of 11.5 to 1, compared to 7.7 to 1 for middle-class schools (California Technology Assistance Project, 2002). Additionally, while there are 23 students per Internet-connected classroom in schools serving predominately White and Asian students, schools serving large populations of Black and Latino students have 37 students per Internet connected classroom (California Department of Education, 2003). National data reveals that 85% of classrooms in schools with low concentrations of students of color are connected to the Internet, yet only 64% of classrooms in schools serving high concentrations of students of color are online (Cattagni & Westat, 2001).

The students who are the least likely to encounter technology in schools also have the least access at home. A recent Pew Internet & American Life report finds that 56% of Latino adults and 60% of African Americans use the Internet, compared to 71% of White adults (Fox, 2007). The same organization finds that while 42% of White families and 41% of Latino families subscribe to broadband access, only 31% of African American households have such access (Horrigan, 2006). The study also finds that 68% of affluent families have high-speed access at home, yet only 21% of low-income families enjoy this broadband access. Though families connecting with a modem can technically go online, they are not able to truly interact with the Internet the same way as those with high-speed access at home because many Web sites utilize multimedia which requires high bandwidth speed. Still, the essential nature of the digital divide cannot be measured by tallying hardware, but rather, must be measured by determining access to rich learning experiences in which technology is embedded.

The "new digital divide": Access to the knowledge & practices of technology. Despite these troubling statistics, the digital divide in schools lies much deeper than simple counts of computers and connections. The Teaching, Learning, and Computing (TLC) study analyzed the relationship between school context, teacher-level professional attributes, and educational technology (Becker, 2000c). The most significant finding of this study is that the implementation of educational technology in classrooms depends on the whole school context—including access to computers, well-prepared and experienced educators, and pedagogical beliefs of teachers. Unfortunately, all of the conditions that support uses of rigorous academic technology—technology access, qualified teachers, and a student-centered pedagogy of high-expectations—are disproportionately absent in the schools that serve low-income students and students of color (Anyon, 1981; Darling-Hammond, 2002; Doherty & Orlofsky, 2001; Harris, 2002).

Many students experience technology in stand-alone courses. Statistical analyses on school curricular offerings reveal how course availability differs between schools serving youth of different demographic backgrounds. In California, Advanced Placement Computer Science classes are overwhelmingly concentrated in schools serving middle class Whites and Asians, while vocationally-oriented technology courses are more likely to be offered in schools serving large numbers of students of color (Goode, 2007). Higher-level computing courses, such as Advanced Placement Computer Science, are an important space for developing an understanding of technology. Additionally, such courses provide opportunities to interact with teachers and classmates around the academic language and scientific reasoning underlying technology. These courses might also provide a learning community which supports the development of one's relationship and confidence with technology, and these courses might entice students to pursue a computer science or related high-tech major. Yet, even if rigorous computing courses are offered at a school site, the presence of these courses does not ensure that all students will find the content meaningful and interesting. Research shows that the software, content, and pedagogy of typical computing courses attract more males than females, contributing to lower enrollment and retention of females (Cooper & Weaver, 2003; Goode, Estrella, & Margolis, 2006; Kirkpatrick & Cuban, 1998; Margolis, Holme, Estrella, Goode, Nao, & Stumme, 2003; Schofield, 1995). Other conditions, such as counselor or teacher beliefs about who should study computers, are also present in this course-taking gender divide.

With the emergence of new technologies, educators have advocated for the integration of computing across academic content areas. This view of computing focuses on *learning with computers*, rather than just *learning about computers*. Yet, even when computers are integrated into academic subjects, the accompanying instruction and pedagogy differs across schools serving students from different social class backgrounds. The TLC survey reveals that students attending schools with large numbers of poor students use computers more frequently in the core subjects of mathematics, English, and social studies (Becker, 2000a, 2000c). However, students in the low-income schools are more likely to use computers to meet the teaching objectives of "mastery of remedial skills" and "working independently". Students in middle-class schools, though encountering computers less frequently, are more likely to use computers to satisfy the teaching objectives of "information gathering," "written expression," "computer skills," "analyzing information," "learning to collaborate," "presenting information to an audience," and to "communicate electronically." These sophisticated and intellectually complex objectives provide a good fit with innovative uses of computers that enrich students' understandings of academic content (Becker, 2000b). Other studies comparing the computing opportunities between high-poverty, high-minority schools and White, affluent schools confirm that the latter group of students are more likely to encounter rich, learning experiences with computers (Margolis et al., 2003; Valadez & Duran, 2007; Warschauer, Knobel, & Stone, 2004; Wenglinsky, 1998).

For college-bound youth attending high-poverty schools, the transition to institutions of higher education, which increasingly rely on an electronic infrastructure, might create logistical, academic, and psychological obstacles. If students feel less technologically prepared than their new classmates, are they less likely to see themselves as high-tech scientists or artists? Can students with little technological proficiency "catch-up" when they get to college? Or is it too late? So far, there is no published empirical research which has captured the multifarious impact of these preparatory disparities and examined how students' unequal computing histories might impact their sense of self, academic work, and future career plans.

Theoretical Framework

There are potentially tremendous costs to not being fluent with technology. Higher education and many professional careers have technology-rich environments, and students without the necessary expertise in computing before they enter college might miss educational opportunities. This paper relies on a theoretical framework that blends the concepts of identity development and the functioning of schools in reproducing the social, economic, and political relationships in society.

A Technology Identity

Computer expertise is more than a set of technical skills—it is a holistic conglomeration of interactions, experiences, and understandings with new technologies. Knowledge about computers might also affect the technology stance of an individual, that is, their attitudes and feelings about technology. Previous opportunities to engage in computing contribute to the formation of a technology identity that encompasses the knowledge and stance a student holds around computers. Using the lens of a technology identity allows an examination of how technological proficiency is developed, how students relate to technology, and the impact of this relationship with the social and scholarly demands which occur on a university campus. Students might not pursue majors in the arts or sciences which include technology if they do not have a sense of comfort with computing. For instance, it is typical to hear students clearly identify themselves as a "computer person" or as "not a computer person." It is the interaction of technological proficiency, stance towards computing, school and home opportunities to build knowledge, and motivation to learn more about technology which impacts the development of a student's technology identity, which in turn shapes students' digital academic experiences.

Identity scholars have devoted great time and attention to describing this term. Gee defines identity as "being recognized as a certain 'kind of person,' in a given context, is what I mean here by 'identity.' In this sense of the term, all people have multiple identities connected not to their 'internal states' but to their performances in society" (Gee, 2000–2001, p. 99). Wenger (1998) relates identity and experiences, noting identity is "a layering of events of participation and reification by which our experience and social interpretation form each other" (p. 151). Looking at identity also "brings to the fore the issues of nonparticipation as well as participation, and of exclusion as well as inclusion" (p. 145). Wenger posits that identities emerge through participation in communities of practice—networks of people who engage in similar activities in which they learn from each other. Membership in such a community of practice "translates into an identity as a form of competence" (p. 153). Learning in communities of practice can take place in both formal educational settings as well as in everyday, informal social situations. While the dialogue around communities of practice often focuses on the role of the novice in the company of a more knowledgeable expert, informal peer encounters also can produce meaningful learning experiences (Brown & Duguid, 2000). Any site with shared discourse, goals, and engagement in technology activities can serve as a technology community of practice. In her important postmodern analysis of technology and the self, Turkle (1995) furthers this line of scholarship. Her research concludes that computers are shaping our sense of self and causing constant re-evaluations of our identities, and as a result, our identities are de-centered and multiple.

Bourdieu's (1986) concept of cultural capital is useful in examining how one becomes a "computer person." Cultural capital in an embodied state, according to Bourdieu, is acquired by an individual, often through socialization processes with family and friends. This type of capital is closely linked to "habitus," or a person's character and way of thinking. In the context of this technology, knowledge and attitudes bestowed by students' communities of practice would qualify as an embodied state of cultural capital. However, in order to take on the habitus as a "computer person," students also need access to the technology itself. Bourdieu's notion of cultural capital in an objectified state includes such access to material goods, including physical technology equipment such as computers, peripherals, and Internet access. It is important to note that without the correct type of embodied capital, students would not be able to adequately "consume" this objectified capital. The third element of Bourdieu's cultural capital considers the institutionalized state of capital. For students knowing about technology, this knowledge and habitus translates into academic credentials, and indeed, qualifications for entry into high-tech majors or careers. Taken together, these three dimensions of cultural capital shed light on the importance of having opportunities to become a "computer person" before entering college where such cultural capital is valued, and indeed, often expected. Yet, rather than providing this cultural capital to students in schools, K–12 institutions often reward students who already have technological proficiency and deny other students access to this vital knowledge.

At the risk of essentializing identity, it is crucial to offer a cohesive technology identity conceptual framework so we can probe the ways that technology shapes the experiences of students. The ideas of participation and cultural capital underlie how one's technology identity is built upon a psychological and sociological interplay between opportunity, knowledge, and attitudes about technology. Martin's (2000) germinal work on mathematics identity provides a useful four-part model of identity based on belief systems which is adopted for this study. Adapted to focus on technology identity, this conceptual framework includes: (a) beliefs about one's own technology abilities; (b) beliefs about the importance of technology; (c) beliefs about participation opportunities and constraints that exist; and (d) one's sense of motivation to learn about technology. Students with a strong technology identity, then, have robust beliefs about their technological proficiencies, believe technology is important, are eager to learn more about technology, and sense there are opportunities to learn more about computing. On the other hand, students with weak technology identities have low levels of technological proficiency, do not view technology as important, do not perceive learning opportunities around technology, and are not motivated to learn more about computers. Most students, however, have a non-linear relationship with technology along these four dimensions due to unique and complex individual experiences shaped by opportunity, knowledge, and attitudes.

It is important to note that one's technology identity is fluid and evolves over time based on new experiences and negotiating meaning from these experiences. Wenger (1998) explains, "We are always simultaneously dealing with specific situations, participating in the histories of certain practices, and involved in becoming certain persons. As trajectories, our identities incorporate the past and future in the very process of negotiating the present. They give significance to events in relation to time construed as an extension of the self" (p. 155). In this sense, students entering college without a strong technology identity may find themselves in communities of practice in which computing is a central component, allowing the novices to gain more competencies around technology. However, since many students declare their academic majors before or during their second year on campus, it is unclear if technologically unprepared students can "catch up" in time to successfully engage in technologically-intensive majors.

Computers Reinforce Social Structures

Many advocates of educational technology point to the ways in which the Internet democratizes knowledge and increases opportunities to communicate across time and space. Predictions of the benefits of new technologies parallel those made about older technologies, mainly, the way that technologies will "level the playing field." However, the work of Bowles and Gintis (1976) revealed that the industrial economy does not democratize access to knowledge, but rather, maintains the social classes of workers. The same is true in examining the introduction of computer technology in educational institutions. Schools, under the guise of meritocracy, reproduce inequalities through the content and implementation of curricula. Thus, students of working class backgrounds typically experience education that offers a "practical" curriculum for the types of jobs that society expects them to engage in as adults. Anyon's (1981) study of elementary schools representing working class, middle class, professional class, and executive elite class backgrounds found that the schools educate students differently and envision knowledge in ways that reproduce social class status. Schools serving low-income students, for example, emphasize the memorization of externally-determined facts as knowledge while schools attended by upper class students emphasize difficult concepts and work within a rigorous, intellectual, and academic environment.

The implementation of educational technology is no different. In fact, computers have become the latest symbol of access to a rigorous, college preparation curriculum. A qualitative research study by Warschauer

(2000) documents how educational technology serves to reinforce, rather than transform, school and social structures. He compares the use of technology in an affluent exclusive private school and a school serving an economically depressed, community of color. Though both schools were in the midst of technology-enhanced school reform, Warschauer concludes that "one school was producing scholars and the other school was producing workers. And the introduction of computers did absolutely nothing to change this dynamic; in fact, it reinforced it" (p. 5).

So far, there has been little research extending these K–12 studies to the university level and exploring the relationship of technology and social reproduction in the academy. The theories of identity development and social reproduction are not two separate lenses for examining the technological needs of college students; rather, these theories complement one another. Academic environments that incorporate sophisticated uses of educational technology in the curriculum represent a community of practice which includes learning the skills, affordances, and language of computing which aid in the development of an academic technology identity. In these environments, students gain habitus around computing. Yet, the socially reproducing nature of schools affords differentiated computing experiences for students, creating inequitable opportunities to develop a technology identity. While students in more affluent schools take on a technology identity based on sophisticated, academic computing experiences, the development of a technology identity for students in working class schools relies on technology encounters that are laden with remedial and vocational objectives. Thus, not having equal opportunities to learn about computers at school limits the critical experiences needed to develop a technology identity. To shed light on how these unequal computing learning opportunities impact college-bound students, the remainder of the paper will report on a study examining home, school, and computing university experiences of undergraduate students.

Methodology

In an effort to begin answering the research questions, this study examined the relationship between the home and school computing history of undergraduate students, their technology knowledge, and the ways that this knowledge shapes their attitudes towards computers, scholarly endeavors, and future career plans. This study employed a mixed methods approach, combining a large-scale student quantitative survey and individual case studies. A mixed methods approach is critical for answering the two different types of research questions. Large-scale quantitative data is useful in determining what educational and social factors contribute to students' technological proficiency and for explaining how students' levels of technological proficiency shape their engagement in university work in general patterns. However, qualitative data is necessary to explain the nuanced effects of how students' technological proficiency, and indeed, their technology identity, influences their academic pathways, attitudes, motivations, and future career paths. For these reasons, this study implemented a sequential mixed methods design (Tashakkori & Teddlie, 1998), starting with a quantitative survey and then proceeding with the collection of technology stories from individual students. Using the framework of Greene, Caracelli, and Graham (1989), these mixed methods designs have many benefits, including data triangulation, an examination of different facets of a technology identity, an incorporation of fresh perspectives, the ability to use data from the first part of study to inform the second part, and more breadth to the findings.

Quantitative Sample

The data collection for this study took place at the University of California, Los Angeles (UCLA) in residential halls. In collaboration with the Office of Residential Life, students from four residential buildings were invited to participate in the study. These four buildings were chosen from sixteen possible buildings by the Office of Residential Life as a representative grouping of the on-campus housing community. The Office of Residential Life "clusters" four communities, each consisting of four buildings: a high-rise dormitory, two plaza buildings, and a suite building. These groupings aim to create a heterogeneous sample for each cluster, as student demographics between the four high-rises, and between the eight plazas, and between the four suites are comparable in terms of ages, ethnicities, gender, student-athlete status, and socioeconomic status. The Office of Residential Life prefers participant sampling of one cluster for each research study, whether the study is internal or external, to protect the time and energy of individual students. But, it is important to point out that students are assigned housing based on their building preferences listed on application forms, incorporating an element of choice into the housing assignment locations. Since this study only includes 4 of 16 buildings, the housing assignment process might potentially skew the representativeness of this demographically-balanced sample. The effect size of the data, therefore, must be considered in this context.

Students from these four residential buildings were invited to participate in the study via e-mail. With instructions from the researcher, residential assistants distributed paper copies of the survey for students who either did not receive an online survey or preferred to answer on paper. Since many students may not have received the e-mail invitation (due to bad e-mail addresses, junk mail filters, etc.) it is difficult to calculate an accurate response rate, but with 513 surveys completed, the minimum response rate would be 24%. Though this minimal response rate might be perceived as low by survey research standards, this percentage mirrors the response rate of other higher education surveys, such as the 22% response rate of the Higher Education Research Institute's "Your First Year College Year" survey (Sax, Gilmartin, & Bryant, 2003). To address possible nonresponse error, this study followed the suggestions of survey methodologists who argue that an examination of the representativeness of the sample is necessary for determining the generalizability of the study's findings (Leslie, 1972; Sax et al., 2003).

Two tests were conducted to examine the representativeness of the sample of college students who completed surveys. First, trend analysis by waves was conducted through a weekly examination of the student responses on technology knowledge dependent variables, confirming that average responses on the selected questions were consistent over time. Trend analysis by waves also confirmed that average response rates by gender and race remained constant over the data collection period. Since wave analysis is based on an assumption that those who return surveys in the final waves of the response period are almost nonrespondents, this analysis suggests that there would not be a significant difference between the replies of responders and nonresponders (Creswell, 2003; Fowler, 2002; Leslie, 1972). Second, survey researchers posit that when respondent characteristics are representative of nonrespondents, low rates of return are not biasing (Dillman, 1991; Krosnick, 1999; Sax et al., 2003). Thus, to examine the sampling of students along majors, a chi-square goodness-of-fit test comparing the academic disciplines of the sample to the general UCLA population confirms that surveyed students are not statistically different from the general population, χ^2 (5, 503) = 1.5, $p < 0.90$. However, demographically, a chi-square goodness-of-fit test showed that the sample's racial makeup overrepresents Asian students and underrepresents Latino students representative to the student body, χ^2 (3, 507) = 16.6, $p < 0.05$. Also, females are overrepresented in this study compared to the larger student population, χ^2 (1, 511) = 64.1, $p < 0.01$. To maximize students' ability to recall high school experiences, underclassmen were purposefully over-sampled to examine how students' technology knowledge impacts their adjustment to college life. Thus, while this sample might be representative concerning disciplinary majors, the demographic limitations of the sample, along with student choice in housing assignments, limits the generalizability of the study's findings to the university student body. Table 1 displays the demographic makeup of the research sample.

Quantitative Data Collection

The quantitative survey assessed the experiences around technology that students encountered at home, in high school, and at university which influenced the development of specific knowledge, skills, and attitudes. There are seven levels of data collected by the survey:

TABLE 1
Demographic Description of Sampled Population

Demographic Characteristics	Percent of Sampled Students
Ethnicity	
African American	2%
American Indian	1%
Asian	49%
Latino	12%
White	36%
Gender	
Female	68%
Male	32%
Age	
18 or under	40%
19	40%
20	14%
21 or older	6%
Family Income	
Under $30,000	19%
$30–$59,999	21%
$60–$99,999	28%
$100,000 or above	32%
Disciplinary Majors	
Arts & Architecture	4%
Engineering	11%
Humanities	10%
Life Sciences	36%
Physical Sciences	8%
Social Sciences	28%
Television, Theater	2%

- *Descriptive data*—This demographic section used seven questions to query students' gender, ethnicity, age, nationality, parents' nationality, family income, mother's highest educational level, and father's highest educational level, and if the student was the first member of the family to attend college.
- *Home access to technology*—This section included three questions querying the age in which the student first used computers, the number of computers available at home during high school, and the type of Internet access available at home during high school.
- *High school access and curricular integration of academic technology*—A total of five questions included queries about the grade level the student first used computers in school for an academic assignment, whether or not the student graduated from a California high school (and if so, the school and district name), and the type of high school attended (public, private, charter, home school, other). Another question asked students the degree to which they agreed to a series of nine statements about high school technology learning conditions, including the degree of technology knowledge of high school teachers, the availability of interesting computer courses, if they learned more about computers at school than any other place, and related prompts. These statements were evaluated using a five-point Likert scale, from "Strongly disagree" to "Strongly agree." The last question queried students if 11 statements applied to them, and asked them to provide a "yes" or "no" answer. These statements included topics such as if students used computers at least once a week in high school, if they had taken a word processing course, if they had taken a computer science course, if they completed a multimedia project, if they applied to college online, and other types of computer use questions.
- *Technological social/cultural capital*—This section included a total of three questions querying if anyone in the student's family worked in the computer industry, whether or not the student had a friend or family member who can fix the computer if it breaks, and the degree to which the student perceived that they knew more about computers than friends, other university peers, parents, and family members. These perception queries on the final question used a five-point Likert scale, from "Strongly disagree" to "Strongly agree."
- *Ability level of students on a series of specific computer activities*—Students were queried on two questions, one with several prompts. The first question asked if they encountered a broken computer, would they attempt to fix the computer on their own, call a friend or

family member for help, call on-campus technology support, call another technology support service, or buy a new computer. The second question asked students the degree in which they felt knowledgeable about a series of 16 computer tasks, including word processing, managing files, e-mail, creating and managing databases, computer programming, and related skills. These statements were evaluated using a five-point Likert scale, from "No knowledge" to "Expert."

- *UCLA access and curricular integration of academic technology*—This section asked students a total of nine questions, including their year of study at UCLA, their major, cumulative GPA, if they had their own computer, whether they had taken any computer workshops at UCLA, if they had designed their own Web page, and if they had downloaded free UCLA software. Students were also asked to report how many hours per day they spent using the Internet for research or homework, using the Internet for another recreational use, instant messaging, e-mailing, and playing video games. Students reported their frequency of 7 academic uses of computing, including using the library's reference database, communicating with professor via e-mail, and using specialized subject-matter software. Students also reported their frequency on these tasks as "never," "once or twice a quarter," "once or twice a month," "once or twice a week," or "three or more times a week."
- *Attitudinal stance towards new technologies*—Lastly, this section asked the degree to which students agreed, using a 5-point Likert scale from "Strongly disagree" to "Strongly agree," regarding 10 attitudinal statements regarding technology use at college. Questions included whether or not students agreed they had made a lot of new friends on campus, if completing assignments takes longer than for classmates, if they completed many assignments on the computer, whether they learned a lot about computers at UCLA, if they avoided classes with heavy technology component, if they had difficulties enrolling in classes online, if they had encountered obstacles due to their computer knowledge, whether professors expected academic technology skills, if there was adequate technology support at UCLA, and if computers had a positive impact on their college experience.

These survey areas mirror the theoretical framework of this study which views technology identity as a complex blend of beliefs about knowledge, attitudes toward importance of technology, opportunities, and motivation. To investigate the social reproductive nature of schooling, students' demographic information and high school experiences were examined in comparison with students' technological proficiency, stance, and experiences with technology at college. The development of these questions was informed and resembled similar items from other studies (Ching, Basham, Jang, Parisi, & Vidgor, 2004; Computer Science and Telecommunications Board, 1999). The survey was carefully designed by the researcher and a university faculty member specializing in educational technology following the validity guidelines set out by Fowler (2002). By paying close attention to question wording, standardized presentation, and unambiguous ordinal scales, all possible efforts were made to increase the validity of the student survey. Additionally, this survey was shared with a faculty survey methodology expert who has extensive experience surveying college students, and a student technology support staff member who is familiar with the technology experience and needs of college students. Based on their feedback the survey was adjusted accordingly to ensure good, clear questions. The survey queried students for their high school information, allowing the survey database to be linked with the California Department of Education school database by the high school each student attended. This link permits a comparison of school-level opportunities to learn (i.e. credentialed teachers, course availability, etc.) with the levels of technological proficiency of students, allowing a third source of information to inform the results of this study.

Quantitative Data Analysis

To determine the degree of technology knowledge students possess, students were asked to select their level of knowledge for 16 skill-based items—from no knowledge (*1*) to expert status (*5*). To include the variety of knowledge students' possessed, a Technology Proficiency Index (TPI) was creating by summing the responses of the Likert-scale answers from these 16 items. Thus, the higher the TPI score, the higher the reported technological proficiency of the student. The resulting TPIs for students ranged from 28–80, with a mean of 52 and a median of 51. The rate of students indicating a *4* or a *5* (near expert or expert) for each skill are displayed in Figure 1. Though the majority of students reported proficiency with basic skills, fewer students reported proficiency with data analysis, design, or computer science skills.

A pair-wise deletion regression analysis was performed to examine how students' social and educational experiences before college related to the TPI students reported. Variables in the categories of demographic characteristics, home access, high school access, and technological

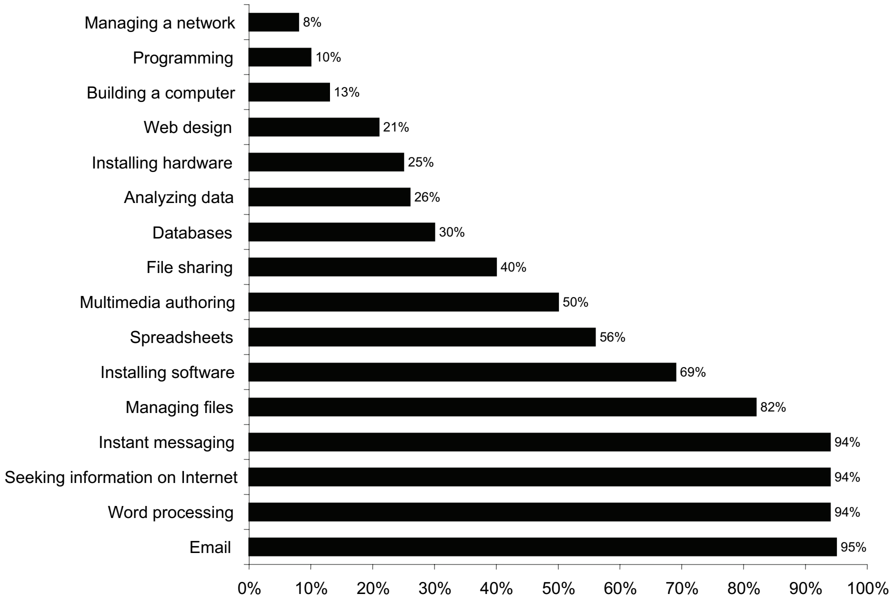

FIG. 1. Students reporting expert or near-expert knowledge in specific technology skills.

social capital were considered for regression analysis. The missing cases resulting from this regression typically had no information regarding the variables concerning the age first used computers, but were not different in any ways that impact the analysis.

To examine the relationship between race and income, analyses of variance and post-hoc analyses using Tukey's HSD post-hoc were conducted. Though students reported 13 different race/ethnic categories, these categories were grouped into five categories for comparison purposes: American Indian, Asian, African American, Latino, and White. With only four students, American Indians were not included in this analysis.

Furthermore, analysis of variance was conducted on the regression analysis independent variables to discern how and if specific race and class-based differences in computing history variables related to students' TPI. To examine the effect of gender, *t*-tests were utilized to distinguish differences between females and males on these variables. Lastly, one-way analysis of variance was used to examine the relationship between technological proficiency for students' attitudes and academic experiences around technology. For this analysis, students were broken into four quartiles based on their TPI scores.

All analyses were conducted using SPSS version 14.0 ("SPSS for Windows," 2004). Not only do the results of this survey shed light onto the proficiency and attitudes that university students have around technology, they also informed the qualitative level of data collection.

Qualitative Sample

Using results from the quantitative instrument, hour-long semi-structured interviews were held with three university students to explore the computing development and consequences for students with different levels of technological proficiency. These three students were chosen for two reasons: they volunteered to be interviewed at the end of their quantitative survey, and they represented diverse ethnic and educational backgrounds and different levels of technological proficiency. With only three case studies, these stories are not meant to be representative of the larger student population. Rather, the stories serve to represent some of the complexities and issues that emerge from the quantitative data and reveal the impact of technology identities on individuals' scholarly and social activities. Thus, these student narratives are presented as explanatory in nature, rather than exemplars of the student body. Due to space limitations, only the two students with the lowest and highest TPI are featured in this paper to illuminate the dramatic influence of technological proficiency on academic endeavors.

Qualitative Data Collection & Analysis

The stories which emerged from these conversations served as a member-check for examining preliminary results of the survey. Conversations followed a semi-structured format, and the questions were guided from the students' responses of the quantitative instrument. This format allowed students to talk more at length about their school experiences with technology, their family's level of computing knowledge, as well as their academic and social lives on campus.

The three transcripts were coded using a grounded theory method (Glaser & Strauss, 1967), allowing reoccurring themes to emerge from the narrative analysis. The analysis was completed using ATLAS.ti qualitative analysis software (Muhr, 2004).

Findings

What Social and Educational Factors are Related to Technological Proficiency?

A standard regression was performed using the Technology Proficiency Index as the dependent variable and data related to home access, high school computing experiences, and social demographics as independent variables. This technique helps address one of the main research questions: *What educational and social factors are related to the reported technological proficiency level of university students?*

Results from the standard regression show that R is significantly different from zero, $F(10, 453) = 17.7$, $p < 0.01$. Most of the missing data occurred on the "age first used computers" variable, but further analysis discovered that this missing data was random and missing responses were not correlated with TPI, race, age, or family income. All of the independent variables contribute significantly to the prediction of a TPI. The individual independent variables account for a total of 19.8% of the variance with the combination of the independent variables added the remaining variance. Altogether, 29.0% (27.2% adjusted) of the variability of technological proficiency is predicted based on variables which account for the access and experiences of home and school computing experiences. Table 2 displays the unstandardized regression coefficients (B), the standard error of the estimate, the standardized coefficients (β), and R^2. Interestingly, race and family income are not statistically significantly correlated with TPI, however, as the following section reveals,

TABLE 2

Summary of Regression Analysis for Variables Predicting Students' Technology Proficiency Index (N = 463)

Variable	*B*	*SE B*	β
Female	–5.53	0.96	–0.24**
Age when first used computers	–0.56	0.16	–0.15**
Two or more computers at home during high school	2.78	0.98	0.13**
High-speed Internet at home during high school	1.80	0.94	0.08*
High school teachers knowledgeable about computers	1.33	0.51	0.11**
Most of technology knowledge learned in high school	–1.11	0.37	–0.14**
Weekly academic use of computers in high school	2.75	1.02	0.11**
Completion of multimedia project in high school	3.71	1.17	0.13**
Completed computer science course in high school	3.56	1.20	0.13**
R^2		0.29	
F for change in R^2		17.13	

Note. $^*p < 0.05$. $^{**}p < 0.01$.

many of the variables included in the regression model are significantly correlated with race and/or family income variables. Inter-item correlation confirms that none of the independent variables included in the regression model have a correlation value of over 0.80 with other independent variables.

Critical Computing Conditions Vary Along Lines of Class, Race, and Gender

This section will examine how race and socioeconomic status interact with the variables shown in the regression analysis to be important in developing technological proficiency. Though race and family income have their unique interactions with these variables, it is important to note the high correlation between these variables. Analysis also reveals that this sample's White population has a significantly higher mean income than Asians or Latinos, and Asian students have a statistically higher family income that Latino students, $F(3,490) = 19.0$, $p < 0.01$. The mean income level of African American students, perhaps due to the small number of students in this category, was not significantly different than other racial groups. Still, some analysis showed significant differences by race but not by income, and vice versa.

The significant social and educational factors which are related to technological proficiency underscore the importance of both home and school for interacting with technology. Though one-quarter of students learned the most about computers at school, most students, including the most technologically proficient students, attribute their expertise to computing experiences at home. While home is a site where valuable, informal learning can happen for youth, school is a place for more formal and academic learning with technology. For students without access to critical computing conditions at home, school becomes crucial for developing technological proficiency. African Americans and Latinos were twice as likely as other students to consider school as the place where they learned the most about technology, $F(3, 496) = 5.1$, $p < 0.01$. In addition, females were one and a half times more likely to report school as the primary site for technology learning than their male counterparts, $t(502) = -3.3$, $p < 0.01$, confirming findings of earlier research (Kirkpatrick & Cuban, 1998). This gender difference might be attributed to differences in recreational video gaming practices—an activity males participate in daily at almost three times the rate of females, $t(509) = 8.0$, $p < 0.01$.

Early Access to Technology

As the regression analysis showed, the age when students first used computers is significantly related to a student's technological proficiency; yet, the age when students first used computers also has a strong relationship with race and socioeconomic status. Data reveals that White children typically began working on computers around age seven, while students of color learned significantly later, around age nine or later, $F(3, 406) = 7.7$, $p < 0.01$. Similarly, low-income students began using technology, on average, around age 10, while more affluent students began computing at age eight, $F(3, 465) = 10.8$, $p < 0.01$. At school, low-income students report using computers in the school environment almost two years after more affluent students first used technology in the classroom, $F(3, 488) = 10.2$, $p < 0.01$.

Home access to technology. Results show that the number of computers at home is associated with technological fluency. Six of ten students in this study report two or more computers at home during high school; permitting less disruption during computing activities than if the computer was shared with the entire family. Also notable and significant is the trend in residential online access. Though just 3% of students did not have any Internet access at home during high school, half connected via modem, and the remainder of students made use of a high-speed Internet connection. Presumably due to the increased cost of DSL or Cable-Internet, the data reveals that twice as many middle-class families as low-income families subscribed to a high-speed Internet, $F(3, 497) = 12.9$, $p < 0.01$. This divide can also be examined when looking at reported online access by racial background, $F(3, 488) = 3.4$, $p < 0.05$. Though half of White and Asian families had high-speed Internet at home, fewer than a third of African American and Latino families had broadband access.

School access to technology. For students without speedy Internet at home, school becomes even more critical for creating opportunities to engage with technology. However, while 87% of the most affluent students surveyed had Internet access whenever needed in school, only 66% of low-income students agreed that the Internet was usually available, $F(3, 488) = 5.17$, $p < 0.01$. In addition to quantitative indicators of access, the quality of computer equipment also varies between schools. Low-income students were less likely than their more affluent counterparts to indicate that high school computers were new and in good condition, $F(3, 489) = 4.56$, $p < 0.01$.

Access to knowledgeable others. With the timeliness of this college generation, it is not surprising that nearly three of four students believe they know more about computers than their parents. Still, the reported technology knowledge of White parents exceeds that of Asians, African Americans, and Latinos, $F(3, 488) = 5.2$, $p < 0.01$. Almost a quarter of students stated they are the first in their family to go to college, and less than half revealed that both parents hold baccalaureate degrees. These first-generation undergraduates are statistically more likely to be students of color, $F(3, 503) = 19.98$, $p < 0.01$, and low-income youth, $F(3, 495) = 26.4$, $p < 0.01$. At school, the students who had the least access to technology expertise at home had less access to knowledgeable and qualified teachers at school. Using the state database linked to students' high schools, an examination of teacher certification rates of students' high schools shows that students of color encountered significantly fewer teachers who hold a state-issued teaching certificate, $F(3, 429) = 21.0$, $p < 0.01$. This study also reveals that low-income students believe their teachers had less subject-area knowledge than more affluent students, $F(3, 490) = 4.5$, $p < 0.01$.

Access to school learning experiences with computing. Though almost three in four students reported using computers weekly in their high school core academic classes, the quality of educational technology they encountered varied. Only one in six students enrolled in web design, video production, or a computer science course in school. Taking one of these courses, not surprisingly, corresponds to a higher level of technological proficiency. However, females reported less availability to technology courses which they found interesting, $t(506) = 32.7$, $p < 0.01$. Though most survey-takers completed a multimedia project in high school, students of color and low-income students were significantly less likely to complete such a digital project, $F(3, 495) = 5.2$, $p < 0.01$, $F(3, 487) = 4.1$, $p < 0.01$. In addition, fewer Latino and African American students were instructed on using their school's electronic library database than White or Asian students, $F(3, 495) = 4.1$, $p < 0.01$. Perhaps the most startling finding though, is the significance of word processing classes for students. Often located in the business department, word processing classes typically take on a vocational purpose. In fact, word processing course participation is actually inversely related to technology knowledge. Though 43% of students in this study enrolled in word processing during high school, low-income students participated in this course at almost twice the rate as more affluent students, $F(3, 488) = 6.7$, $p < 0.01$. With an emphasis on word processing for low-income students, it is not surprising that low-income students are significantly less likely to agree that high school offered interesting computer course, $F(3, 489) = 3.5$, $p < 0.05$.

How Do Students' Technological Proficiency Impact University Work?

Data gathered from the survey results uncovers how opportunities and technological proficiency can impact university academic work. To examine how technological proficiency influences attitudes and academic motivation, students were sorted into quartiles based on their TPI. Table 3 notes how gender and socioeconomic class is related to low- and high-levels of technology knowledge. Table 4 reports results from a one-way ANOVA showing how technological proficiency levels impact attitudes towards computing. All items show a significant difference in means based on TPI quartile, and Tukey's HSD post-hoc analysis confirms that the means are statistically significant between the lowest and highest quartile of TPI students. The qualitative findings of this study add more depth to examining how prior computing experiences and technological proficiency impacts the work of college students.

TABLE 3
Distribution of Students into TPI Quartiles

	Lowest Quartile of TPI	Highest Quartile of TPI
Females	30%	16%
Males	14%	41%
Low-Income	33%	20%
High-Income	19%	27%

TABLE 4
Students Who "Agree" or "Strongly Agree" on Relationship to Technology Items

	Lowest TPI Quartile	Highest TPI Quartile	*df*	*F***
I love working on computers	38%	85%	3, 488	33.52
I have downloaded free university software	25%	45%	3, 484	4.42
I complete many assignments on computer	62%	85%	3, 482	6.97
Assignments take longer than for peers	36%	16%	3, 482	9.28
I avoid courses with technology	30%	2%	3, 483	47.48
Technology has been a positive experience at college	61%	84%	3, 482	7.56
I am interested in a technology-rich major	22%	49%	3, 488	29.58
I am interested in a technology-rich career	3%	47%	3, 488	37.58

**All effects statistically significant at the $p < 0.01$ level.

The Technobiography of a Technologically-Underprepared Student

The case studies reveal how technology experiences lead to technological proficiency, which in turn corresponds to affective relationships with computers. The narrative of Lara, a low-income, Latina freshman, exemplifies how low technological proficiency impacts university work. Lara is ranked in the lowest quartile of technological proficiency compared with her university peers. Lara never used computers at school during her experience as an East Los Angeles high school student. Her cousins gave her family a computer when she was in 11th grade, but she had no online access. No family members have any knowledge about computers, and her teachers never used technology, so Lara taught herself to use word processing and presentation software for school assignments. Yet, rarely did technology actually enhance learning in academic subjects. As Lara explained:

> I had no computer assignments in school. It was up to you to type or not, the English, history, and science classes the teachers would recommend it, so they could read it easier and stuff, but never required to use the computer. For computers, in history or biology, if you wanted to get a better grade or impress the teacher, you would use PowerPoint, but you wouldn't have to. It was just a matter of impressing the teacher. You would look determined to get a better grade because you used technology.

As a result of her minimal experiences with computers before college, Lara states that "I don't know a lot about computers, just enough to survive." She recently switched from a science to a humanities major, revealing her sense of under-preparation compared to her peers to complete her science assignments. Lara struggled to use the specialized science software, had no technological support, and generally felt uncomfortable in the science learning environment. Though it is difficult to claim that technology was the primary factor in her decision, it certainly played a role. But despite her decision to switch majors, she continues to encounter obstacles because of technology outside of the classroom.

A heartbreaking example of how deeply Lara's lack of technology knowledge impacts her university studies was revealed during a Saturday morning interview with Lara. She commutes to the university campus from her family's home by bus, taking three hours roundtrip. On the date of the interview, she explained that she travels to campus each weekend to check her e-mail and access the library database because her family could not afford an Internet provider. The university never informed Lara that the all students receive free dial-up access from any location in the Los Angeles area. Without this knowledge, Lara came to campus twice a week exclusively to connect to the university network. Nobody ever told her about the campus' virtual resources, despite her participation in a summer minority preparation program and the university orientation program. Since Lara's friends at college are also novices with technology, she has no peer support in building her technology knowledge. This waste of valuable time, in addition to her schoolwork and part-time job, became another burden for Lara.

Lara's story illustrates how high schools fail to prepare low-income students and females for the technological demands of college, and how the university fails to support students' emerging technology needs. Certainly, schools need to be guided by universities to better prepare students for the high-tech demands of campus life. But universities also need to build in support networks to proactively aid students like Lara, who do not have rich home technology experiences. As she wisely noted, "During orientation they gave us a tour of campus so we'd know where all the buildings were. But they didn't teach us about how to enroll in classes online. I could have just found the buildings with a map—they should have taught us about the computers."

The Technobiography of a Self-Identified "Techie" Student

Scott is a White, middle-class student who grew up in the Central Valley of California. Scott first used computers in school during 4th grade, and enrolled in a Web design summer school course in elementary school. However, most of his computing learning experiences occurred in an informal environment at home with his father's guidance. As an electrical engineer, his father was quite proficient with technology, and there were always multiple computers at home available for Scott to tinker around with. As he recalls:

> My dad bought a computer, I don't remember the year, it was a long time ago, an IBM, before they had hard drives, with a yellow string, where you stick the disc in. Back then. It was really neat, he had it, one day he got upgraded to a newer computer, so I got that. It was very basic, you'd bring up the screen have six options, you could do a cooking program, play a game, . . . The fact that it was mine now, I was coveting his, I was always "I want to play, I want to play" and then finally. From then on, when he would upgrade I would get the old computer, or be able to use it more, and I could put games on it, and could do that.

During high school Scott's family subscribed to high-speed Internet access. Scott used this high-level access to develop Web sites and play video games. These opportunities to learn about technology resulted in Scott's ranking in the highest quartile of TPI compared to other students involved in this study.

As a result of his rich K–12 computing experiences, Scott has a strong identification with computers. He integrates technology throughout his academic and social endeavors on campus. He makes use of the school's free technology resources, workshops, and available software. As an aerospace engineering major, he has used a variety of disciplinary software, such as flight simulators, in his coursework. Due to his in-depth computing knowledge, Scott was also hired in the campus' student computer store as a salesperson and troubleshooter for computers, peripherals, and software. He also uses his extensive knowledge to save time and money. Scott buys subsidized computers and software based on his student status, then sells the technology online, making a sizeable profit. He also buys his textbooks online, saving hundreds of dollars each academic term. Most of Scott's friends are also into technology, and together, they assist one another with technical problems or other computer-related issues. His fluency with technology benefits his life, drives his future career plans, and is at the core of his academic and social identity. As he explains "I'm a technophile. I like having the latest gadgets."

Discussion

Technology as a Symbol of Social Reproduction

The inequitable distribution of critical computing conditions for students is extensive in California. Students with less access to hardware, software, and Internet at home are the ones least likely to be able to go online for meaningful computing experiences at school. Students who do not have academically or technologically knowledgeable adults at home, like Lara, are the ones least likely to be given a qualified teacher who is skilled with instructional technology. And without access and knowledgeable others, the students who depend on school the most for digital interactions are the ones who receive the lowest translation of computer literacy courses. These findings corroborate the work of social reproduction scholars (Anyon, 1981; Bowles & Gintis, 1976; MacLeod, 1987; Willis, 1981) and scholars examining school-based computing opportunities along lines of race and class (Becker, 2000b; Cooper & Weaver, 2003; Goode et al., 2006; Kirkpatrick & Cuban, 1998; Margolis et al., 2003; Schofield, 1995; Warschauer, 2000; Warschauer et al., 2004). The curricular opportunities for students to engage with technology mirror their social class—poor students are more prone to use computers to word-process, affluent students are more likely to be offered Advanced Placement computer science courses, use the computer weekly in school, and complete multimedia projects within academic courses. In fact, wealthier students even get a jump start in using technology earlier than low-income students in the classroom setting. This story reveals that rather than serving as a great equalizer, schools' unequal opportunities for students to learn about technology perpetuates the digital divide.

This study furthers the conclusions of scholars who examine how technology is a tool which acts as a broker to social reproduction in K–12 education and extends the findings to higher education. The results reveal the influence of unequal K–12 schooling on college students and demonstrate how students' technological proficiency is dependent on access to knowledgeable teachers and curricular experiences involving computers in high school. The findings also outline how the university continues to perpetuate elements of social reproduction through their implicit assumption of technology knowledge and the university's focus of technology support services to the students who possess the most technology knowledge. As the technobiographies revealed, Scott, amongst the most technologically proficient students, utilizes most of the digital campus resources, while Lara, desperate for knowledge of these resources, is left without assistance.

The affordances of knowing about computers are exceptionally significant in this digital, information-age. Based on the importance of technology on our economy, digital expertise can be considered, "high-status knowledge." As Apple (1990) asserts, "The possession of high-status knowledge, knowledge that is considered of exceptional importance and is connected to the structure of corporate economies, is related to and in fact seems to entail the non-possession by others. In essence, high status knowledge is 'by definition scarce, and its scarcity is inextricably linked to its instrumentality' " (p. 36). Simply put, the existence of the digital divide provides the high-status knowledge reputation of computing. Rather than countering this digital divide, schools are rewarding students who have home advantage with this "high-status knowledge" while limiting access to this important knowledge for students who rely on school the most.

Technology as an Identity

The outcomes of this study offer a snapshot of university students along the four facets of a technology identity: knowledge, attitudes, opportunity, and motivation concerning technology. Though these belief categories are interrelated, they serve as a unique construct for measuring important elements of students' technology identities. Based on the findings of this study, one's technology identity cannot be fully developed without an initial foundation of rich learning opportunities which build knowledge and an understanding of how and why technology might be important. Analysis of the quantitative data emphasizes the importance of being exposed to communities of practice involving technology before students enter high school. Without proper opportunities to develop the sense of being a "computer person," students are less likely to develop proficiency and interest in deepening their knowledge around computing. The strong influence of Scott's father reinforces the importance of having opportunities, in the form of access to technology and computing knowledge, to develop a sense of identity around technology. In contrast, Lara's lack of access to computer equipment as well as limited interaction with technologically knowledgeable adults and peers restricted her opportunities to develop a strong technology identity, despite her positive attitudes and interest in computers.

Students' relationship with computers is closely related to the experiences they have had, and will have, with technology. Elements of a technology stance include general disposition towards technology, personal affect towards the role of computers in life, and sense of competency with digital tools. This study confirms that a positive stance towards computing is inextricably linked to digital proficiency, which is contingent on meaningful learning experiences with technology. The students with the most skills, the highest quartile of TPI, are significantly more likely than the least skilled students to express love towards computers and a desire to learn more about technology at college. Scott's strong identity with computers, compared to Lara's lukewarm reception of technology, displays the range of these attitudes. Of course, a positive relationship towards computing activities does not have a one-direction relationship. More experiences with technology corresponds with more positive feelings towards computing, which in turn might contribute to additional interactions with technology which build more knowledge.

The impact of a strong technology identity on university work appears to be tremendous. Not having a strong technology identity, in fact, causes students to actually avoid classes that might incorporate technology due to a lack of technology skills, attitudes, and/or motivation to work with technology. Overwhelmingly, students without a strong technology identity do not regard computing encounters in college as positive. On the other hand, students who have a strong technology identity are more likely to interact with computers in positive ways that support schoolwork. The most technologically proficient students, such as Scott, also use computers to save time and money—two valuable commodities for university students. Meanwhile, Lara's story of wasting valuable time to check e-mail, in between school and a part-time job, demonstrates the great sacrifices students might have to make due to their limited knowledge and experiences with technology. Despite her interest and motivation to learn more, her low level of knowledge and lack of opportunities to learn more about computers continues to negatively shape Lara's university experiences.

The findings of this study also highlight the importance of Bourdieu's conception of cultural capital. Not only must students have cultural capital in an embodied state through access to computers and high-speed Internet at home to increase their technological proficiency, but this study also showed the importance of socialization, especially at school, for building knowledge around computers. Furthermore, the powerful correlation between students' technological proficiency and their attitudes with computers reinforces the importance of the embodied state of capital. Students with extensive computing knowledge are much more likely to love computers and make use of university technology resources. The findings of the study confirm that this cultural capital around technology can also be viewed from an institutional state. Students with high levels of technological proficiency note that they intend to exchange their cultural capital for economic capital as they progress through their academic careers; they are more likely to take courses which integrate tecnology, major in technology-rich disciplines, and pursue technology-rich careers.

However, it is critical to situate an examination of a student's technology identity along with other identities that students might hold. As Turkle (1995) points out, identities in the digital age are de-centered and are characterized by multiplicity. This research study hints towards the importance of considering the intersectionality of technology identity with a gender identity. The findings illuminate a gender divide in examining reported computing knowledge and attitudes towards computers. Females reported less technological proficiency than males, confirming prior research findings of a gender divide (Cooper & Weaver, 2003; Goode et al., 2006; Kirkpatrick & Cuban, 1998; Margolis et al., 2003; Schofield, 1995). Since males were much more likely to report spending time playing video games, perhaps gaming is an activity which leads to increased technological proficiency and positive attitudes towards computing for males, as it did in Scott's narrative. This hypothesis might also account for why females were much more likely to indicate that they relied on school as their primary learning site about computers, since they typically did not spend as much time at home gaming as their male classmates. However, though females learned the most about technology at school, they expressed a higher level of disinterest in the available courses than their male counterparts. Simply having access to technology is not enough, rather, students need to be interested and identify with the integration of educational technology in order to gain knowledge and develop a positive stance towards computing. Furthermore, these differences by gender around the development of a technology identity might reflect the influence of having few role models in the technology industry or in their friendship groups that females can emulate and consolidate their gender identities with being a "computer person" (Goode et al., 2006). This gender dimension of a technology identity underscores why technological proficiency and stance towards computing must both be considered when examining access issues and computing.

Clearly, students enter university with varying levels of technology identities. It is important to note, however, that technology use is not optional at the college setting. It is simply not possible to avoid technology as a twenty-first century university student. Even if students choose to study in disciplinary fields that do not integrate a high level of technology, they are still required to use computers to access the electronic infrastructure of the college and communicate with peers and professors. Enrollment, financial aid, virtual course management environments, scholarship/internship opportunities, and other vital information systems are exclusively listed online in many university settings. Additionally, a sense of general belonging in college is also related to technology identity. For students who are not as technologically prepared as their peers, a sense of broad under-preparation may cause students to question their general academic abilities. Lara's story of transferring from a science major to a humanities major offers some powerful insight on how subtle, psychological effects of a low-technology identity might inhibit university work. Meanwhile, students with a strong technology identity, like Scott, thrive in high-tech majors which have a great transfer value in the economic sector.

Overall, these findings point to the importance of high schools in preparing college-bound students for the demands of higher education and the responsibility of higher education to support the digital needs of incoming students. Currently, schools seem to be perpetuating the digital divide found in the home setting, privileging students who already have a home advantage and denying academic learning opportunities for the students who most rely on school in developing fluency with computing. When students enter college, they immediately encounter a technology-rich atmosphere, and their technology identity has a tremendous influence on how they navigate academic decisions. Yet, students with the lowest technology knowledge benefit the least from university digital resources and support programs designed specifically to benefit the student body. With the important conclusions of this study in mind, K–16 policies must be created that support all students in developing the technology knowledge and skills necessary for college success, across disciplines.

Policy Recommendations

Many proponents cite new technologies as democratizing information and providing a space for important political and social participation. In addition, computers are valuable learning tools for students, and technology knowledge is increasingly required for scholarly success and future marketability. Yet, costs of access and other issues preventing students from interacting with computers continue to perpetuate the digital divide. Schools and universities have a unique opportunity to directly tackle this equity issue.

Though this study sheds light onto the digital inequities in California schools, it also points to the need for collaborative work on this issue. Due to the rapid infiltration of technology, there has been little understanding about the consequences of technology preparation for students as they enter college. Though this study only involved one university, the findings point to the failure of statewide policies on preparing and supporting college students in their use of technology. The results of this study point to the need for teachers and counselors from K–12 schools, higher education administration and faculty, as well as students and community members, to come together and work on creating an academic technology pipeline for students. Schools need to know about the technology demands of higher education to best prepare secondary students, and universities need to understand the ways in which students interact with technology in school to support students as they transition into college. Without the public education system taking responsibility for the digital demands of students, the least-prepared students will be burdened with an additional obstacle that affects their academic, social, and financial lives as they begin college.

In the meantime, colleges should not assume that students have the resources to learn about technology as needed. They should not direct most of the technology support to the students who perhaps need it the least—the ones holding the highest level of technological proficiency. Programs such as freshman orientation should aid students as they adjust to the digital requirements of the university. Technology support programs need to proactively seek out students who require additional help, rather than wait for students to discover such aid, as many students without the skills do not understand what they are missing. After all, if public schools do not prepare students for university studies, then it is the responsibility of the University, as a public institution, to support students work to bridge, rather than ignore, the digital divide.

Digital knowledge is important not just because of its economic value, as many believe, but also because of the digital saturation of technology in popular culture and democratic participation (Mossberger, Tolbert, & Stansbury, 2003). Knowing about technology is important in hip-hop culture, in youth culture, in the arts, and in the sciences. Providing students academic channels in which to funnel this knowledge creates opportunities to learn more about academic content areas, as well as become more knowledgeable students in our democratic society. In California, where the information revolution emerged, students are being denied equitable opportunities to engage with the digital tools that build high-status knowledge.

Limitations of Study

Though this study laid the framework for examining the ways in which students experience technology at college, there are several limitations to this research. First, the site of this study is not an average college campus; instead, it is an elite place of higher education that reflects student populations typical of large AAU research institutions. This means that most, if not all, of these students experienced the best education their school offered and were most likely part of the highest academic track of students. Furthermore, due to this study's limited sample and treatment as a particular case, it is not possible to make generalizable conclusions to all institutions of higher education. However, the study's conclusions do highlight the need to further investigate the influence of the digital divide at particular institutions. A similar study at a regional university would allow researchers to compare and contrast the integration of technology and support for students across university systems, and across high school academic tracks. Second, the lack of racial diversity in higher education severely dampers research on pathways of students of color, particularly African American students. With such low representation at UCLA, it is problematic to make generalizations about how African American students interact with technology in higher education. Finally, though this study investigated the relationship between academic majors and technological proficiency and use, more information is needed to better understand the ways in which students in different disciplines experience technology. Continued research, both quantitative and qualitative, is needed in this area.

Conclusion

This study began with the supposition that schools serving low-income students and students of color provide inferior academic technology experiences for students, inhibiting the development of students' technology identities. The results reveal that university students have deeply integrated the role of technology into their social and academic lives. Still, there is a range of knowledge students possess, with low-income students and females falling at the low end of the spectrum. The data reveals how unequal school computing experiences vary along lines of class, race, and gender. Students' opportunities to learn—including teacher technology knowledge and digital curricular experiences—impacts technological knowledge and skills. The study also describes how students with the lowest levels of technological proficiency actually avoid courses with heavy technology components, while the techiest students reap the academic and social rewards, including time and money, of knowing about technology.

The data informs our understandings of how the technological stance of students affects entry into college, and how different computing backgrounds influence attitudes and computing knowledge. More broadly, this study aims to shed light on the ways in which technology serves as an instrument of social reproduction, allowing some students the opportunities to engage in rigorous academic computing experiences and denying other students valuable skills needed for higher education, especially the knowledge needed to study within technology-intensive academic disciplines.

The results from this study point to the urgency in developing K–16 policies that make explicit the academic technology knowledge and attitudes expected of university students, the role of high schools in preparing these students, and the responsibility of the university in supporting the technology needs of its students. We must go beyond developing skill sets when considering the technology needs of students and also address opportunities to learn more about technology, attitudes towards computing, and motivation to learn more about technology. Only then will educators and policymakers address this severe imbalance of high-status knowledge and prepare all of its students for the digital demands of college life and civic participation.

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